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VRML Programs for Room Ventilation Applications

Anker Nielsen

VRML PROGRAMS FOR ROOM VENTILATION APPLICATIONS

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ABSTRACT

Cheap 3D models for visualization of room ventilation applications are now available. VRML (Virtual Reality Modelling Language) is found to be a good format to describe buildings, rooms and furniture. A 3D model in VRML can be placed on a World Wide Web (www) page and others can see the model in "Walk Through" mode. The use of VRML is described by examples, as for instance in planning of measurements and as a basis for geometry in CFD calculations. The advantage of 3D and VRML is the fact that it is much easier to see, find and correct problems than using traditional drawings. 3D models on the Internet are a new possibility for better exchange of ideas.

KEY WORDS

CFD, Modelling, Virtual Reality

INTRODUCTION

Visualization of geometry in measuring and modelling is important for a good description. Visualization is also very important for presentation of the results of measurements and scale modelling or full-scale experiments. This is rather easy in two dimensions as we can make drawings on paper, but in most practical cases we have three-dimensional (3D) geometry. This makes a presentation more difficult – we have to select sections or use specialized 3D data visualization software that is designed for viewing 3D data sets from arbitrary viewpoints. This has in many cases involved expensive

software, and it is difficult or impossible for other researchers to view the data on their own computer from other viewpoints.

Using technology that originally was made for computer games on the Internet can give better and cheaper methods for 3D visualization. We can place a 3D model on a World Wide Web (www) page that can be accessed from everywhere, and you can see the model from the viewpoint you want from your local computer.

This paper contains references to www pages. I use the symbol www (x) as a reference to site x, which is found in the reference list.

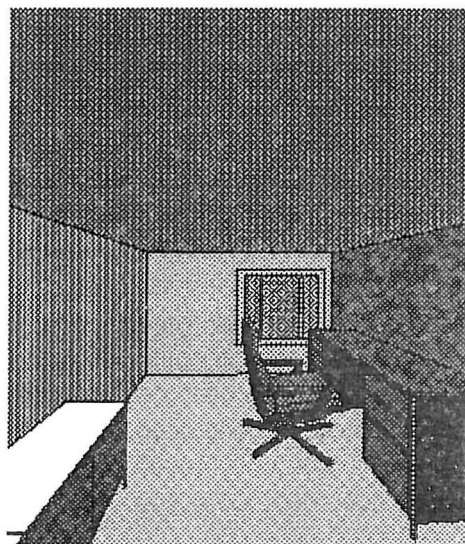


Figure 1. Internal view of a VRML room model made with the method described by Smith (1995).

3D DRAWINGS

Five to ten years ago, a real 3D drawing program was very expensive and needed to be executed on workstations or mainframe computers. Today, the situation has changed completely - you can buy a 3D drawing program for 30 to 125 US\$ off the shelf. In these cheap programs you can get most of the functionality from the older large systems. These programs as for instance *www* (6, 10, and 11), are typically used to make architectural layout of rooms with furniture and fixtures. The program can show the result as 2D plans or 3D drawings with colours and textures on the surfaces. The program package includes libraries of predefined 2D or 3D objects as boxes, tables, chests, chairs, doors, windows and so on. It is therefore easy to construct a room or a building with 3D objects. In the following examples I use cases with rooms but it could have been whole buildings. It is also possible to customize objects for the model. It can be a new model of furniture to get at more realistic 3D model.

VIRTUAL REALITY AND WALK THROUGH

During the last years a new 3D file format has emerged - the Virtual Reality Modelling Language (VRML). This language started as a method for distributing 3D geometric information via the Internet. It defines a "world" consisting of blocks, cylinders, etc. from which the user can build rooms and buildings. The VRML describes a 3D world you can walk into and explore by "walking around" by different programs, "browsers", which are available on almost all machine platforms. An example is *www* (9). This gives the possibility of constructing games with rooms and static objects in VRML version 1.0 *www* (3), where you can "walk through" and see the world from different angles. In VRML version 2.0 *www* (4), and VRML 97 *www* (5) objects can be moved by the user and

taken to another room. This gives a virtual reality, where you can change your world on the screen and see the results. The newest definition is VRML 1997, which is also an ISO standard.

```
#VRML V1.0 ascii
Separator { #Polyhedron
DEF COORD0 Coordinate3 {
  point [
    0.0000 2.0000 -4.0000,
    0.0000 2.0000 0.0000,
    -3.0000 2.0000 0.0000,
    -3.0000 2.0000 -4.0000,
    0.0000 0.0000 -4.0000,
    0.0000 0.0000 0.0000,
    -3.0000 0.0000 0.0000,
    -3.0000 0.0000 -4.0000
  ]
} #Coordinate3
Material {
  ambientColor 0.2118 0.1696 0.1196
  diffuseColor 0.8471 0.6784 0.4784
  transparency 0.0000
} #Material
IndexedFaceSet {
  coordIndex [
    0, 1, 2, 3, -1,
    0, 3, 7, 4, -1,
    1, 0, 4, 5, -1,
    2, 1, 5, 6, -1,
    3, 2, 6, 7, -1,
    7, 6, 5, 4, -1,
  ]
} #IndexedFaceSet
} #Polyhedron
Separator { #Polyhedron
```

Figure 2. Example of VRML model for a room of 4 x 3 x 2 m. First section defines coordinates for the eight corner points. Second section defines the colours, and third section the six surfaces in the room.

The VRML format is easier to parse than other often used 3D formats and it is not too complicated to use. Figure 2 is an example of the definitions of a room. The first section defines the coordinates (x,z,y) for the eight corners. The second section defines the material properties: colours and transparency of the surfaces. In this case all surfaces have the same colour. The third section defines the six surfaces in the room. Each surface is defined by a number of corners ending with -1. The numbers 0 to 7 are the first

to the last coordinate in the list in the first section.

At Narvik Institute of Technology we have found this language to be a very useful tool for 3D visualization of simple geometry, and as a basis for technical calculations, see Nielsen (1996, 1997, 1997a) and Nielsen and Bang (1996).

EXAMPLES

The use of VRML models that can be "Walked Through" in room ventilation applications includes visualization of rooms, planning of measurement, geometry for CFD calculations and presentation of measuring results. Information on other places to find examples and information on 3D visualization and VRML is found on www (8).

Visualization of a room

In planning of full-scale measurements or calculations on a room, is it important to be able to see the geometry. In most cases we will have plan and section drawings, but as room ventilation is three-dimensional it would be interesting to get a 3D view of the room or building. This can be done with the cheap CAD programs that can make a model in VRML. Some of these programs are also able to read and translate DXF/IGES formats from for instance AutoCAD. This is interesting if the building has been constructed by a CAD system that writes files in that format. If we do not have CAD files we have to build the model ourselves.

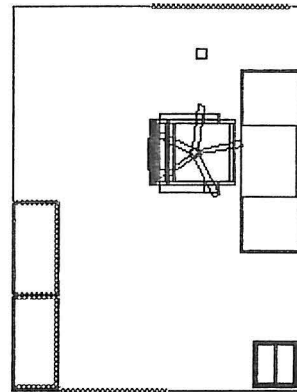


Figure 3. Plan of an office.

Figure 3 is a plan of a 12 m² single cell office with furniture taken from a VRML model used in the reference Nielsen (1997a). Figure 1 is a view seen from the door. It has taken less than one hour to make this 3D model as doors, windows and furniture were taken from predefined objects in the program.

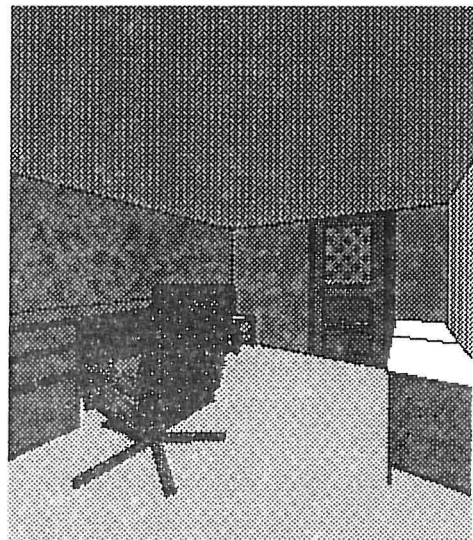


Figure 4. Internal view from window side.

Figure 4 gives a view from inside the office. This office is found at www (1), where you can visit it by means of your VRML browser. At the same site you can find many other rooms.

Measuring points in rooms

It is not always easy to explain where the measuring points are located in a room. In the office shown in the figures 3 and 4, we have three measuring points for temperatures 40, 120 and 180 cm above floor level. These points are located 40 cm from the exterior wall with the window, and 100 cm from the long wall where the desk and the chair are located. This definition is not easy to understand without a plan drawing of the room.

By using a plan drawing to mark the points it is easier to understand the definition, but we can make it better by using a 3D presentation. If we have a VRML model we can mark the points as coloured boxes placed at their exact locations. Figure 5 is a picture of the same cases that were described in writing at first. Using a VRML browser we can look at the room from different viewpoints, and see if these points are placed as required. The case can be found in [www \(1\)](#). In this case we can see that the point in 120 cm's height is in front of the window and will be affected by solar radiation. If we had a radiator below the window it would influence the radiation temperature of the lower point. We can also see that a person sitting in the chair is quite near to the measuring points and might influence the results.

The 3D VRML model is a useful tool in planning of actual measuring situations as we can make a model of the room and, without too much work, place furniture and persons in the room. Different measuring points for temperature, airflow and other parameters can be shown by boxes of different colours.

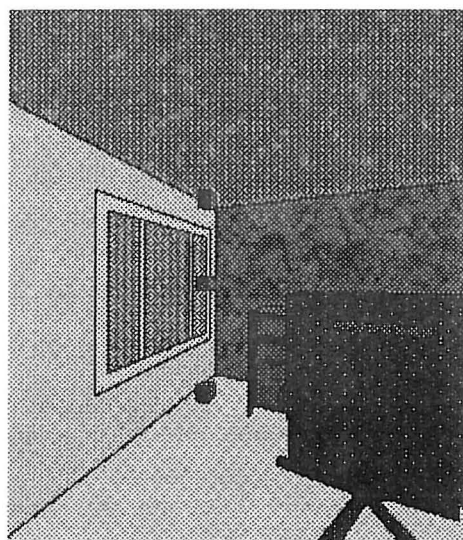


Figure 5. Three measuring points (marked by boxes) in an office room.

CFD geometry

It can be time consuming to give geometry input for CFD programs. In many cases we will have to make simplifications. Here, a 3D VRML model can help us. If we start by making the model in VRML we can use browsers to see the model and to find out if the geometry is as requested. We can also see where we can make simplifications. Making the VRML model might look as extra work, but we can use a program that can convert from VRML to STL format. This format was originally made for producing stereo lithography models, and it describes surfaces as triangles. The format can be read into for instance the CFD program Flow-3D [www \(13\)](#), and calculations can be made without much trouble. This has been done at Narvik Institute of Technology. By using this method it is possible to work on the geometry with cheap data programs with a good presentation of the 3D environment.

The steps in the conversion are shown in figure 6.

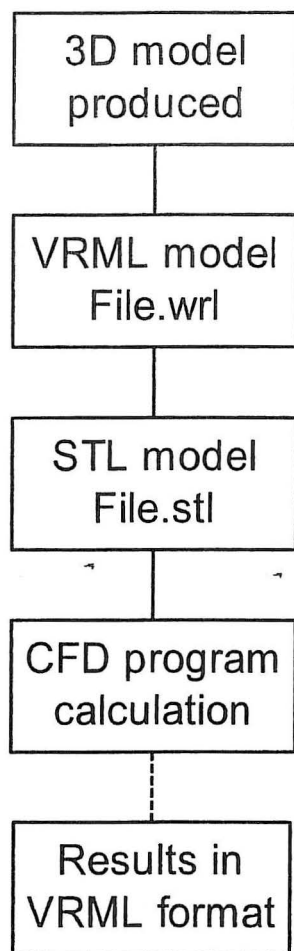


Figure 6. Steps from 3D models and VRML to CFD calculations.

Planning of room

The VRML model is useful for the planning of the location of the furniture. This is important for a good indoor climate as dust can settle on horizontal surfaces, which are difficult or impossible to clean. Information on this is found in the reference Nielsen (1996, 1997a). Another example is the layout of ventilation rooms. A 3D model makes it easier to see if there is space for the equipment and for mounting and maintenance. Figure 7 is a view of a ventilation plant described by Nielsen (1997).

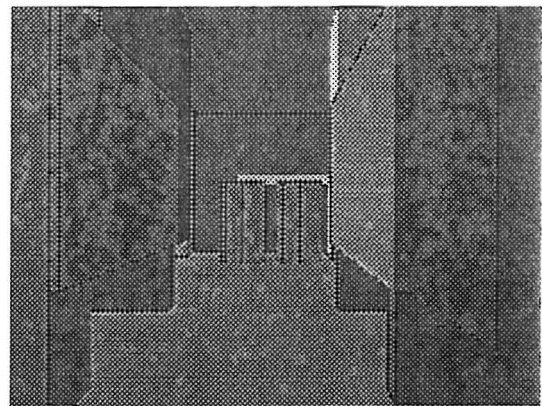


Figure 7. Ventilation room constructed by VRML.

Visualization of CFD results

Traditionally, visualization of results from CFD calculations as temperature, airflow and pressure is made either in the CFD programs or by specialized visualization software. The features included can be isosurfaces, isolines, streamlines, cutting planes and arbitrary viewing. It is easy to see the results from different viewpoints if you are on the same computer that contains the data and software, but not if you are on other computers without the software. The problem can be solved by using a VRML model that can be placed on a web page. This has been done at the School of Computer Science at the University of Leeds. They also have a web page about VRML on www (12). Figure 8 is from a course in visualization, and it presents a picture from a visualization of the airflow in a window cavity. The large sizes of the arrows indicate the large air speed. The colour is brighter for high speed than for low speed. In order to see the VRML model you must go to www (2) and use a browser for VRML. In that case you are able to “go into” the model and see the results from the interior of the model. Figures 9 and 10 are two views. If we use a more complex model we should be able to see the airflow, but that will give a much larger file, and more time for the file to come up on the screen.

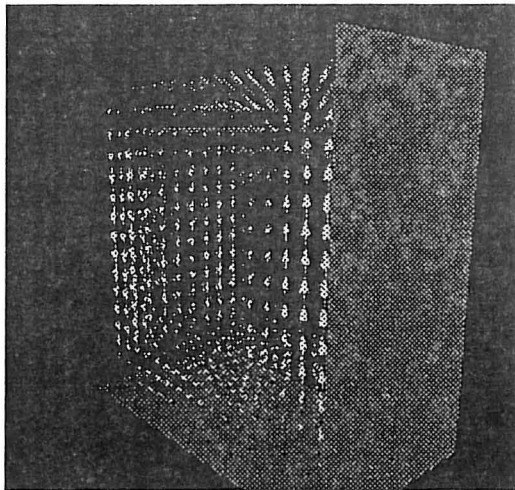


Figure 8. Airflow in a window cavity calculated by Yeap www (2).

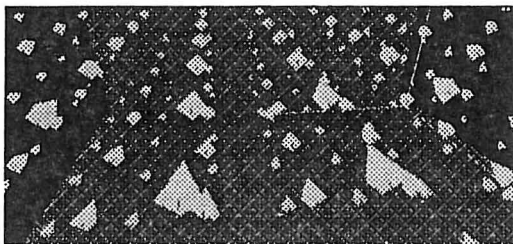


Figure 9. Inside the airflow seen from a browser.

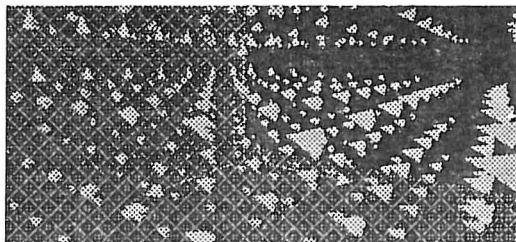


Figure 10. The airflow from another point.

Visualization of surface temperatures

If we have calculated or measured surface temperatures for a room it is possible to place the results as a texture on the surface of the VRML model. It is then much easier to see the effects in the corner of the room and the variations when we go from floor to wall. This has been tested and it works well, but the model can be slower to start as texture files can be rather large. This method can also be used for presentation of thermographic pictures of room surfaces.

Figure 11 shows air temperatures inside the wall cavity from the last

section. The temperatures are given as colours on selected surfaces which we can "walk into" with our browser.

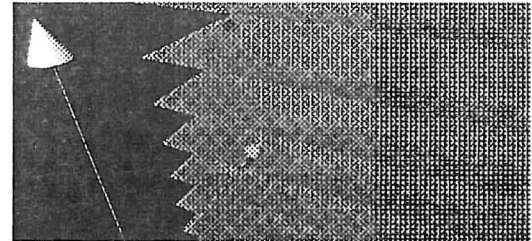


Figure 11. Air temperatures in a cavity.

Construction of VRML models from pictures

It is also possible to construct VRML models of rooms or other objects from pictures. The use of digital cameras makes this a practical method without using too much time. The problem is to make corrections depending on the camera optics and camera position. This can be made by a program as Photomodeler www (7) with an accuracy of 1:1100 for a good digital camera.

The best method is probably to construct the VRML room from the drawing, and then take pictures to find out furniture types and their location in the room.

CONCLUSIONS

This paper presents examples of the new possibilities for using cheap 3D models for visualization in room ventilation applications. This includes planning of measurements and control of geometric models. It is also possible to use VRML as a tool to present results from for instance CFD calculations. A 3D model with VRML can easily be placed on an Internet page, and you can ask others to look at the model and give comments based on their own experience from a "Walk Through". It is much easier to see and find problems in a 3D model.

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Smith, D. et al. (1995) Virtus VRML Toolkit, Hayden Books, USA, 1995, ISBN 1-56830-247-9.

www sites

These references to www sites can change during time, as the web is dynamic, so if you do not find the page, then search the web using the text information given for each site. Note that some names continue over more than one line and must be written without breaks.

www (1) Anker Nielsen, Narvik Institute of Technology, Box 385, N-8501 Narvik, Norway <http://www.hin.no/~an/>

www (2) Yeap, T.S.L., Visualization M.S. Course- work 2, Double Glazing Visualization, University of Leeds, School of computer science
http://www.itl.gov.sg/iti_people/iti_staff/ravex/personal/lu_cw/vis/cw2/welcome.html

www (3) VRML 1.0, The Virtual Reality Modelling Language, Version 1.0 Specification, Gavin Bell, Silicon Graphics, Inc. , Anthony Parisi, Intervista Software , Mark Pesce, VRML List Moderator
<http://www.vrml.org/VRML1.0/vrml10c.html>

www (4) VRML 2.0, Specifications, August 1996
<http://www.vrml.org/Specifications/VRML2.0/FINAL/spec/index.html>

www (5) VRML 1997, International Standard ISO/IEC 14772-1:1997
<http://www.vrml.org/Specifications/VRML97/>

www (6) Virtus VRML:
<http://www.virtus.com/>

www (7) Photomodeler:
<http://www.photomodeler.com/>

www (8) List of VRML-sites:
<http://www.hin.no/~an/privat/virtual-web.htm>

www (9) Cosmo Player: VRML-browser
<http://cosmosoftware.com/>

www (10) Trispective 2.0
<http://www.eye.com/>

www (11) VRCreator Personal edition
http://www.platinum.com/products/appdev/vream/vrc_ps.htm

www (12) VRML and JAVA 3D information centre
<http://www.scs.leeds.ac.uk/vrmljava3d/>

www (13) Flow-3D CFD-program
<http://www.flow3d.com/>

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